# 26. Boiling water

Team Croatia

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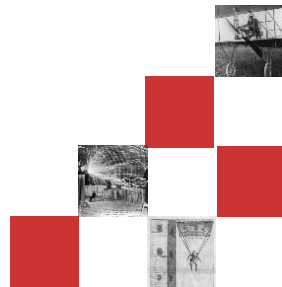
# Problem statement

A **noise** if heard if **water** is **boiled** in a **kettle**. Investigate how this noise changes with time

# Introduction

Three phases:

1. nucleation
   - solubility of non polar gases
2. cavitation
   - bubbles bursting
3. surface popping
   - bubbles popping



# Nucleation

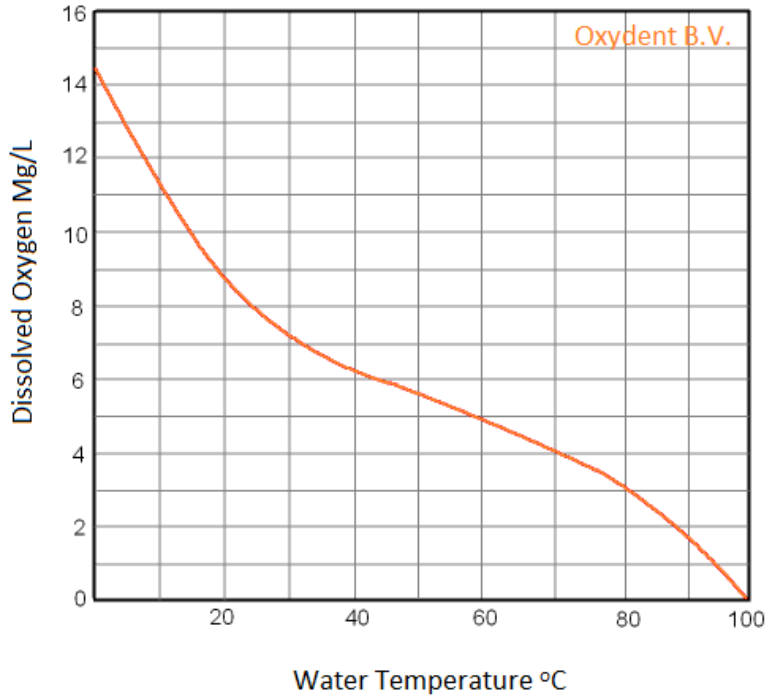
**Solubility of non-polar gases**

- solubility decreases with increase in temperature

$O_2$

- air bubbles → trapped in water → climb to the top layer

- forming of air bubbles



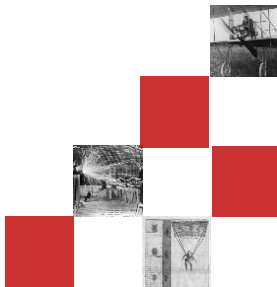
# Cavitation

**Different layer temperature**

- newly formed bubbles move up through the layers of water above

- upper layers of water → relatively cooler
  bubbles lose E → collapses and bursts before reaching the surface

- shockwaves generate a loud noise



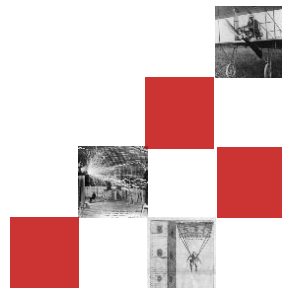
# Surface popping

**Bubbles popping**

- Temperature about to reach 100ºC

  bubbles have enough E → reach the surface → gently pop

- All steam gets to the top → noise stops



# Hypotheses

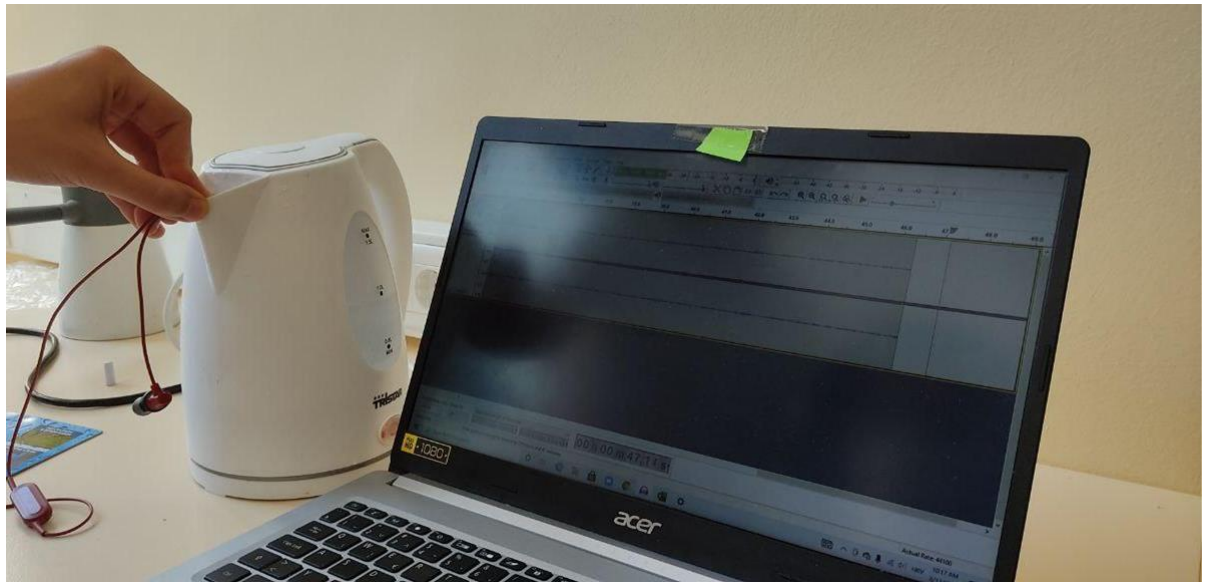
H1: The **sound intensity** will **increase** with **temperature** until the boiling point

H2: During the **boiling process** there will be **three phases observed with different dominant frequencies in each phase.**

# Experimental setup

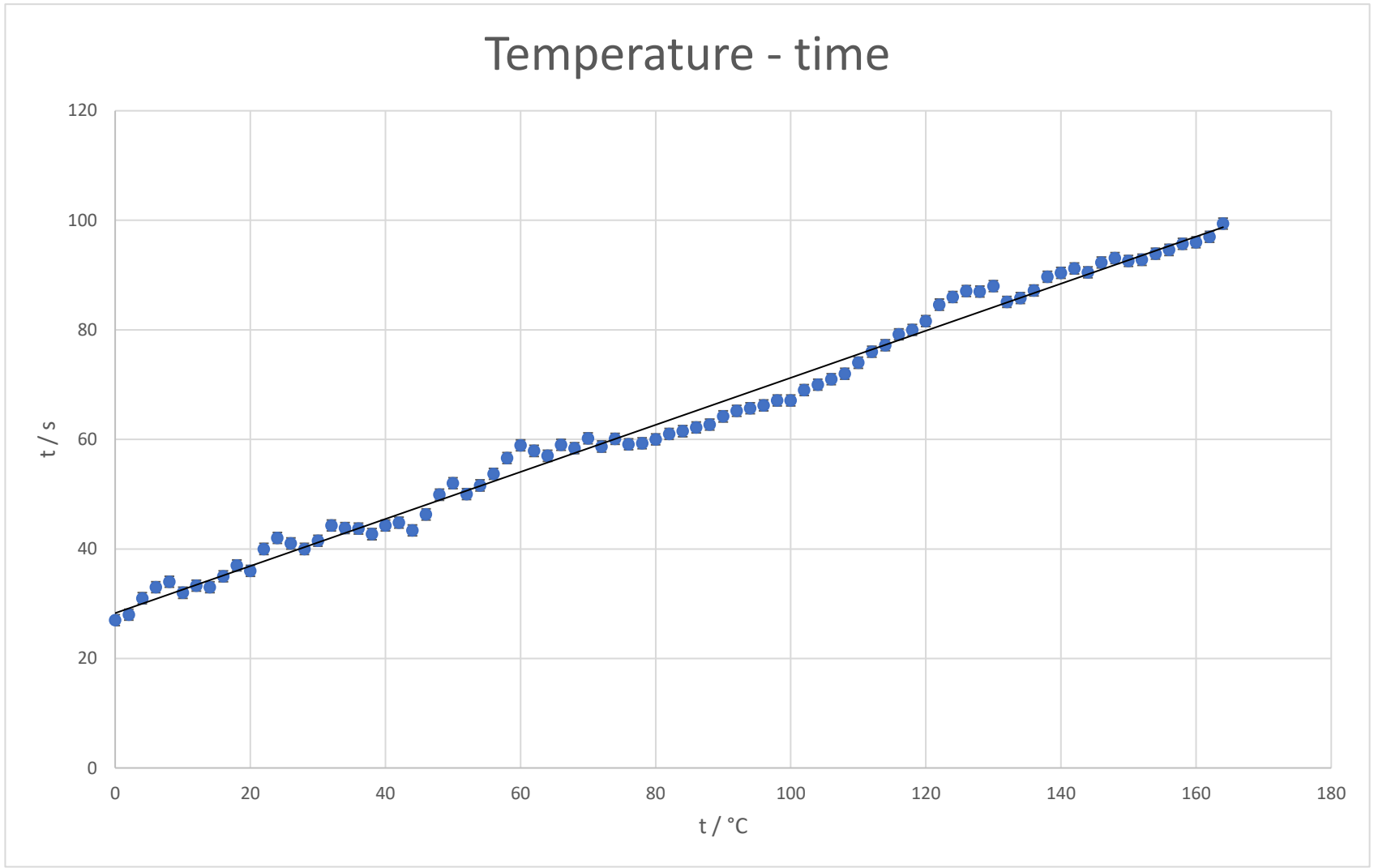
**Materials**

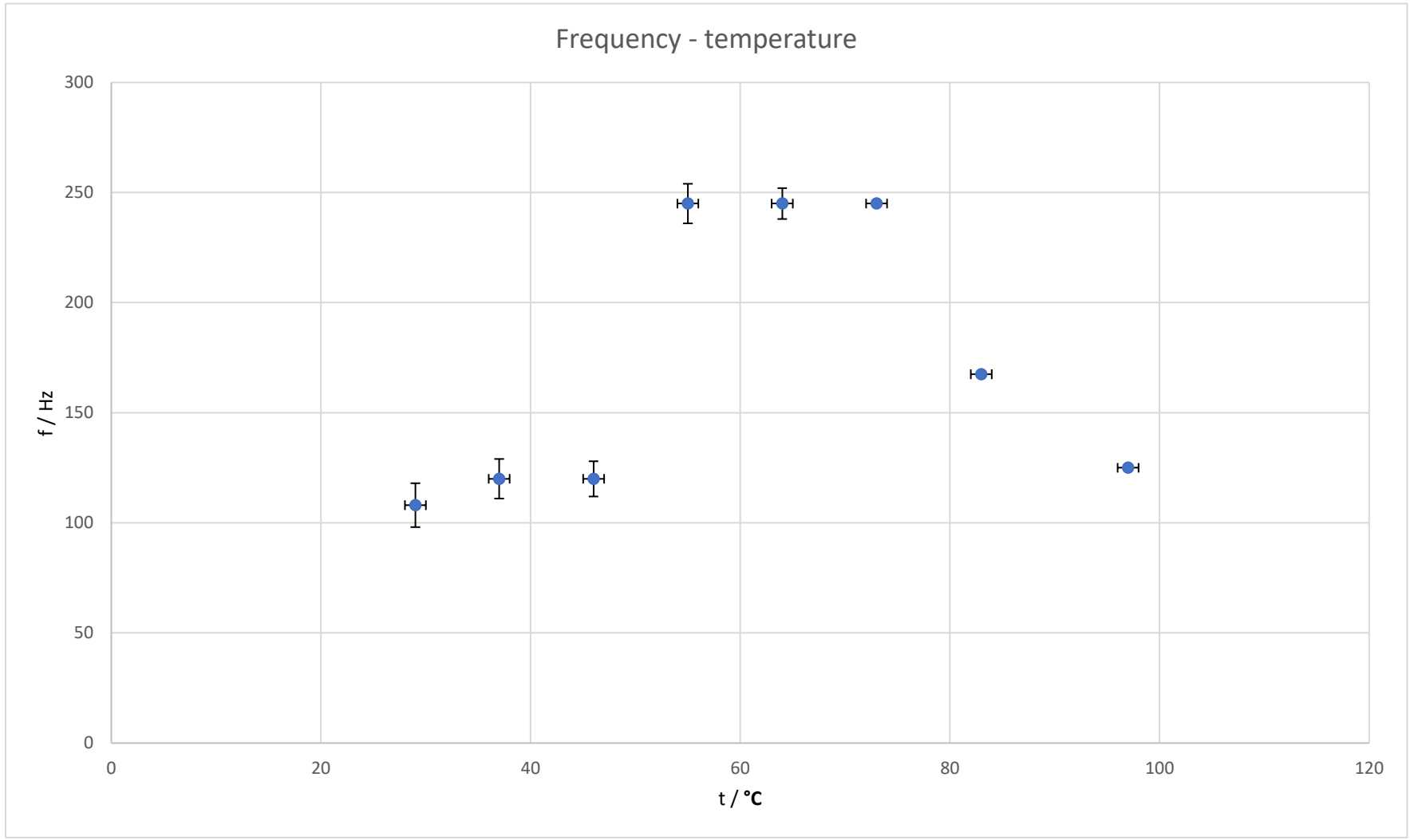
- regular plastic kettle
- heating plate (2100 W)
- thermometer $\pm 0{,}1$ °C
- headphone microphone

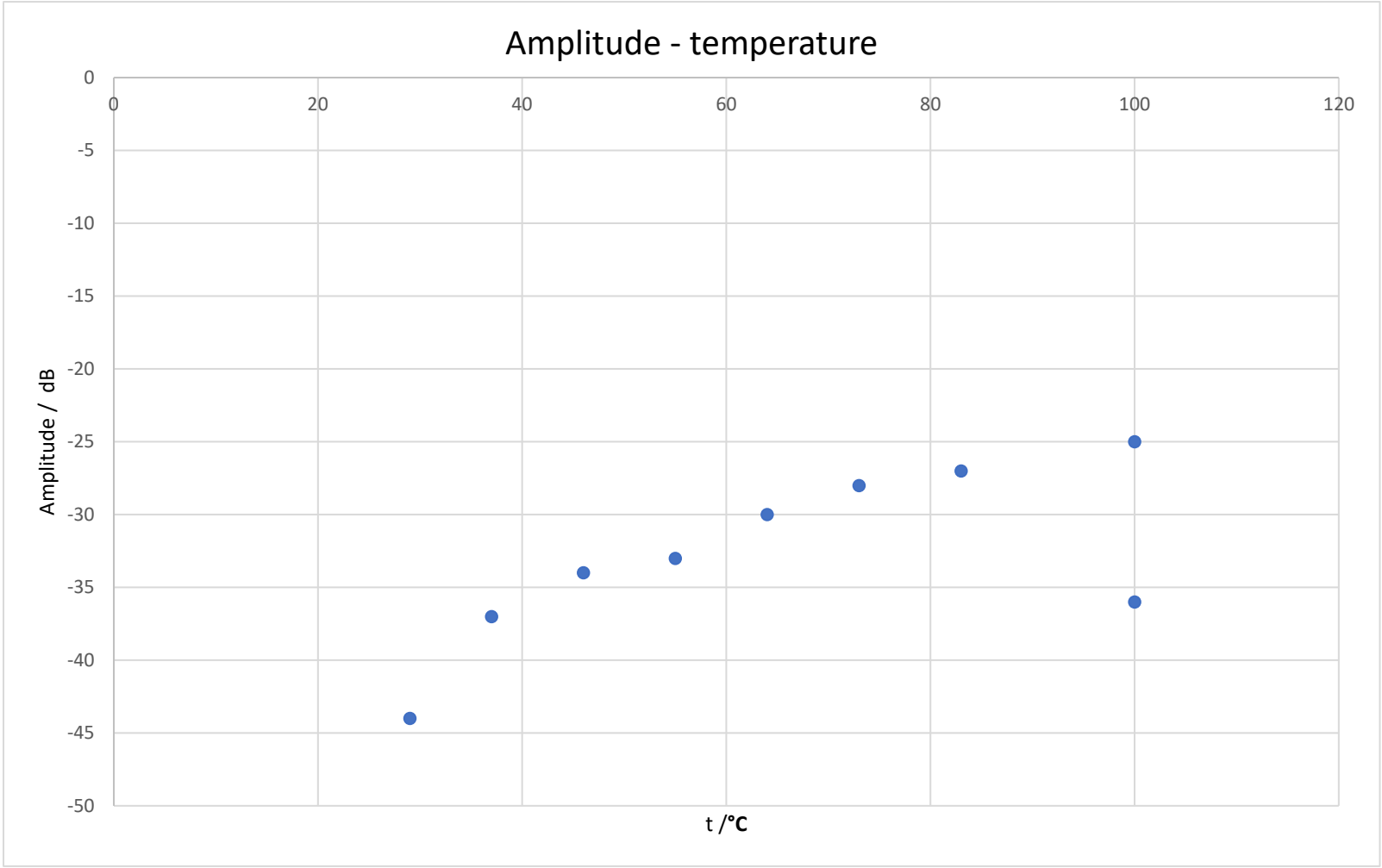



**Experimental method**

1. filling the kettle with water (1 L)
2. temperature measured every 2 s
3. sound capturing
   fixed distance from headphone microphone
4. analysis in Audacity -> plot spectrum
5. 5 repetitions

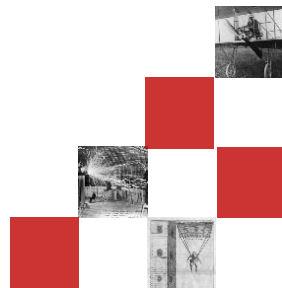

Temperature - time
120
100
80
60
40
20
0
t / s
0
20
40
60
80
100
120
140
160
180
t / °C


Frequency - temperature
300
250
200
150
100
50
0
f / Hz
0
20
40
60
80
100
120
t / °C


Amplitude - temperature
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
20
40
60
80
100
120
Amplitude / dB
t /°C

# Conclusions

- ✓ The **sound intensity increased** with **temperature** until the boiling point
- ✓ During the **boiling process** there were **two dominant frequencies** for three phases, same dominant frequencies we're observed in first and last phase.

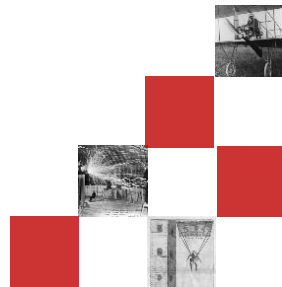


# Literature

https://www.scienceabc.com/nature/why-is-water-loudest-just-before-it-boils.html

https://eu.citizen-times.com/story/news/local/2021/05/17/why-does-boiling-water-make-noise-softer-what-causes-noise/5080751001/

Serway, Jewett: Physics for Scientists and Engineers



# Thank you!

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